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Thermal Management of Microprocessors

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Overview

- Thermal management challenges of Eighth-Generation AMD Athlon™ Processor
- Heat sink and hardware design elements
- AMD thermal reference solutions
- Development partner interaction

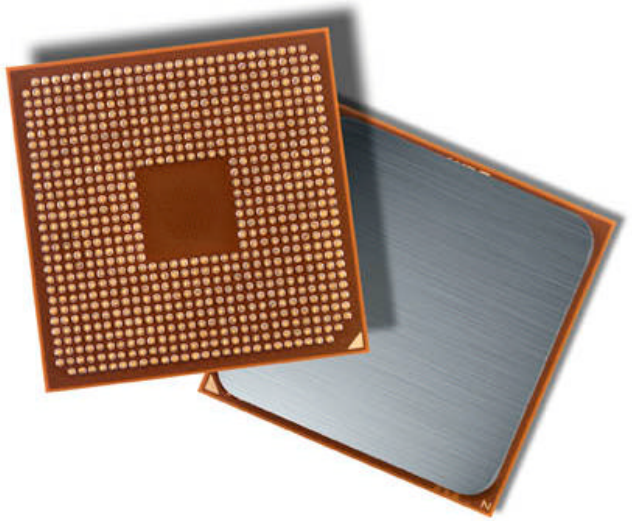


AMD's Thermal & Mechanical Engineering Design Goals

- Enable devices to maintain processor temperature within specified limits
- Ensure robust, user friendly mechanical attachment
- Enhance acoustics of solutions
- Enhance the ease of use of AMD processors

Eighth-Generation AMD Athlon™ Processor

- 754-pin µPGA organic package
- 40 x 40 mm package size
- Nickel-plated copper lid



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New Mechanical Challenges

- μPGA surface mount socket
 - Solder joint reliability must be top consideration
 - Socket contacts cannot support any tensile loads
- Motherboard referenced mounting scheme
 - Excessive flexing of PCB

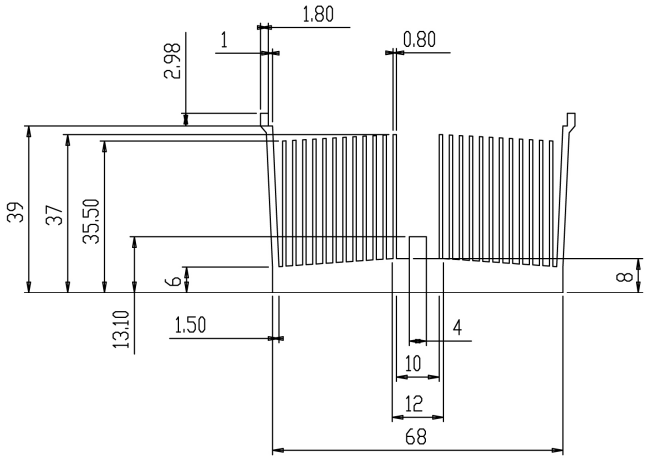
Thermal and Mechanical Requirements / Recommendations

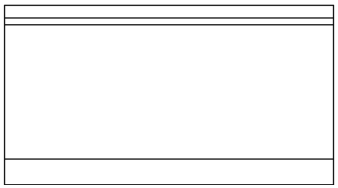
- 450 gram maximum heat sink mass
- High-load clips to retain heat sink during shock and vibration events (75 lbs)
- Utilize back plate to reduce PCB bowing
- θ_{CA} targeted at 0.27 – 0.37 °C/W
- Leverage low cost manufacturing technologies

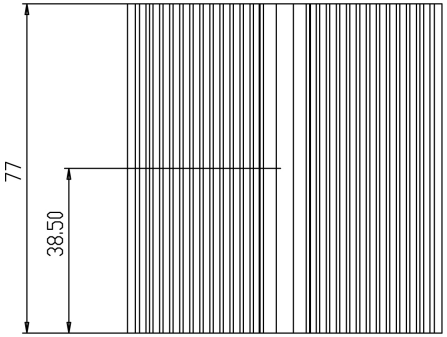
Heat Sink Design Parameters

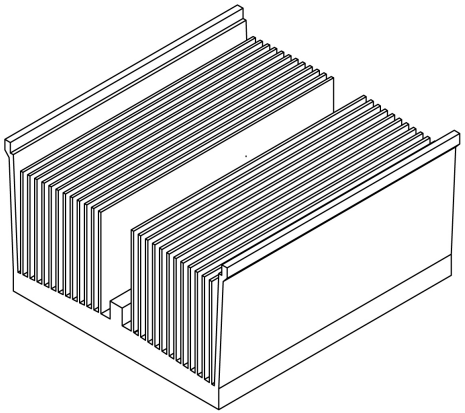
- Heat sink base size is 68x77 mm
 - Allows use of multiple fan sizes
- 450 gram maximum mass
 - Allows for high density fin technologies
 - Allows the use of copper for enhanced heat spreading
- Maximum cooling solution height is 60 mm
 - Recommended within the ATX specification

Example Heat Sink 1





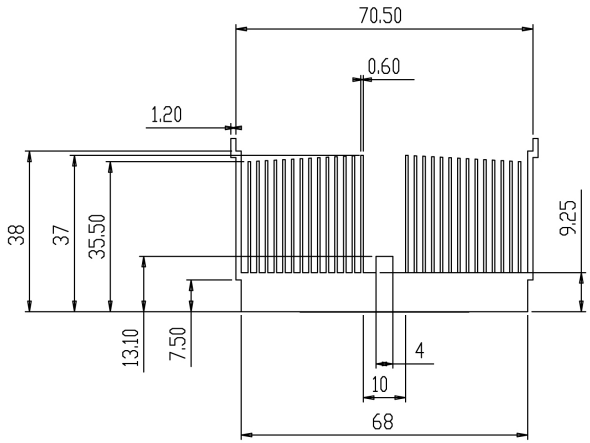


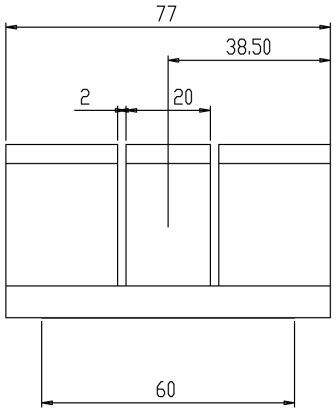


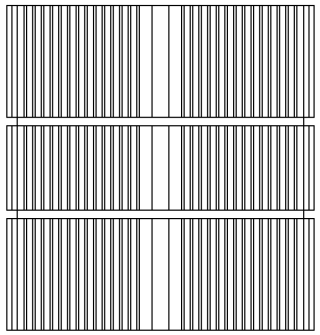
- All aluminum extrusion
- 70 mm fan
- Approximate mass of 250 grams w/o fan

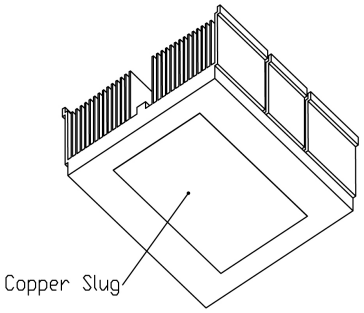
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Example Heat Sink 2





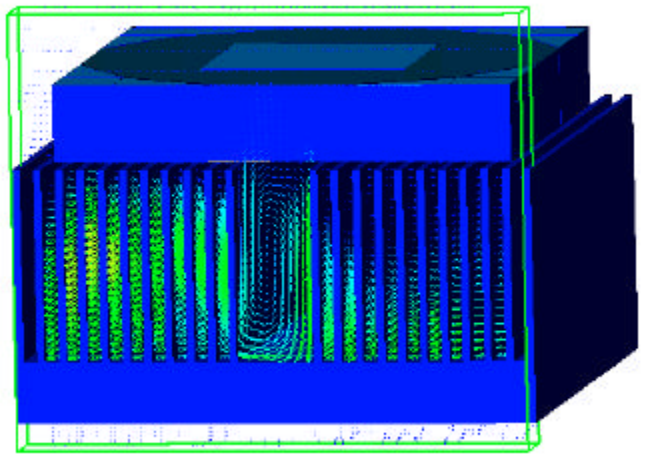


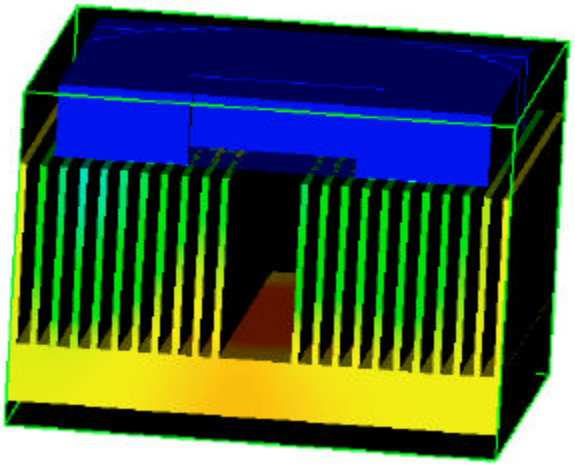


- Aluminum & Copper hybrid heat sink
- 70 mm fan
- Approximate mass of 320 grams w/o fan

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CFD Simulations of Heat Sinks





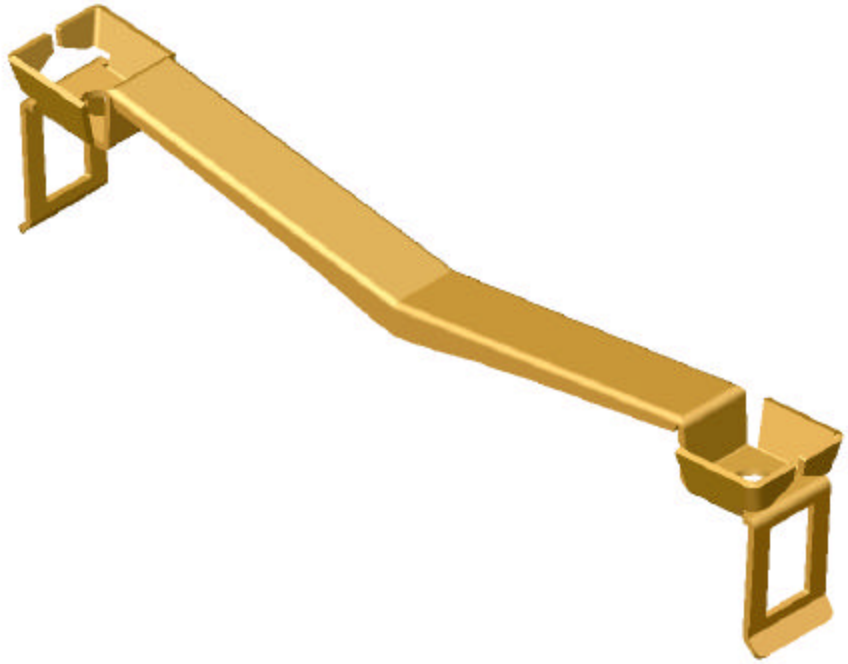
- Flotherm models
- Optimization of geometry before prototype

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Required Clip Force

- Electrical requirements drive use of a surface mount socket
- No tensile forces can be applied to socket solder joints to maintain reliable connections
- Heat sinks must always have a force pushing them against the processor
- Dynamic loading in shipping may cause heat sink to pull processor out of socket unless clip load is large enough to prevent movement
- 75 lb load meets above requirements

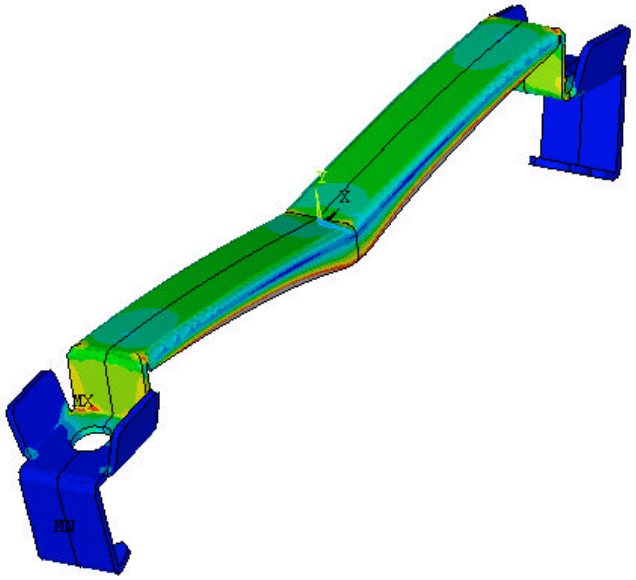
Reference Clip Design

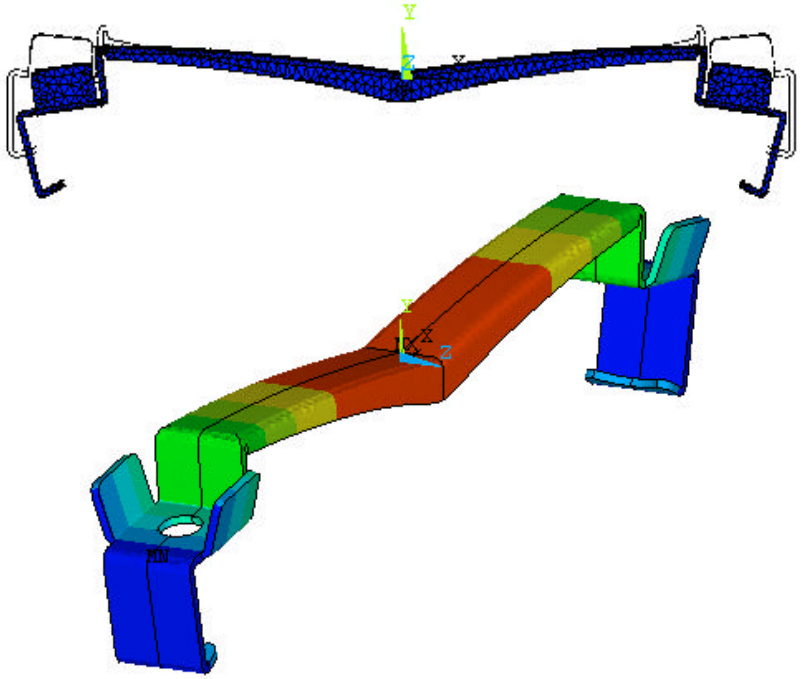


- Heat treated spring steel, SK7
- Screwdriver retention fence

FEA Analysis of Clip Design

- Stress analysis to avoid plastic deformation

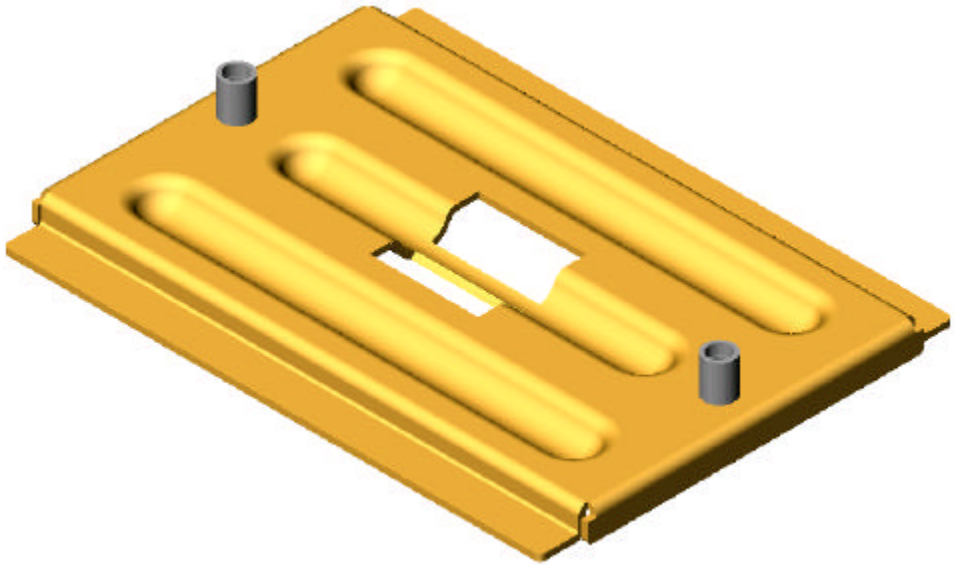




- Force-deflection analysis

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Reference Backplate Design

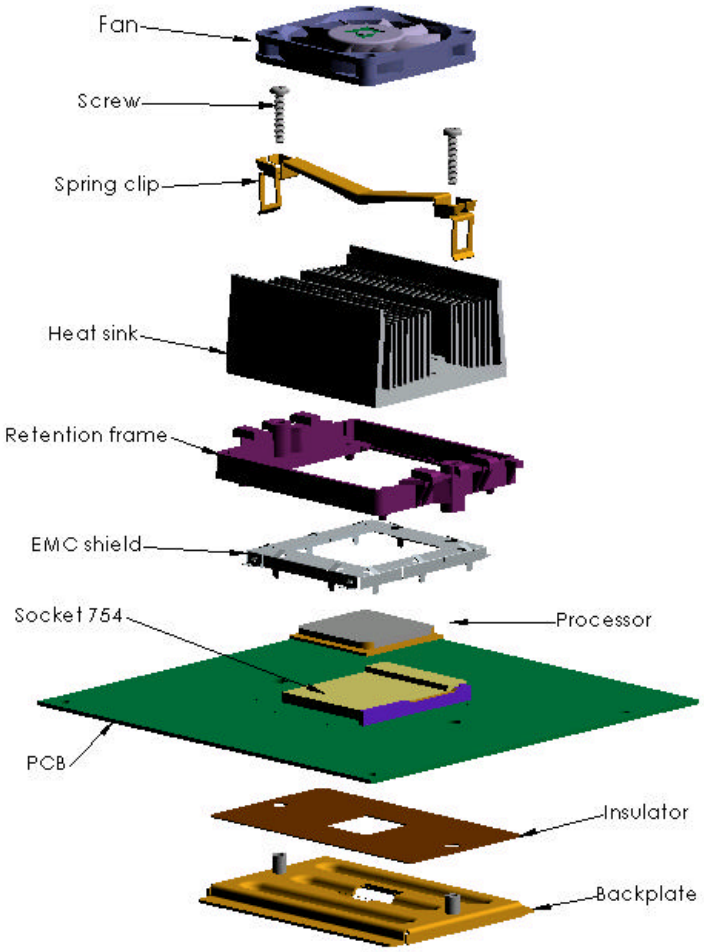


- Low carbon steel
- #6-32 PEM standoffs for mounting points and alignment aid
- Plate thickness < 4 mm
- Plastic backplate under development

Advantages of Backplate

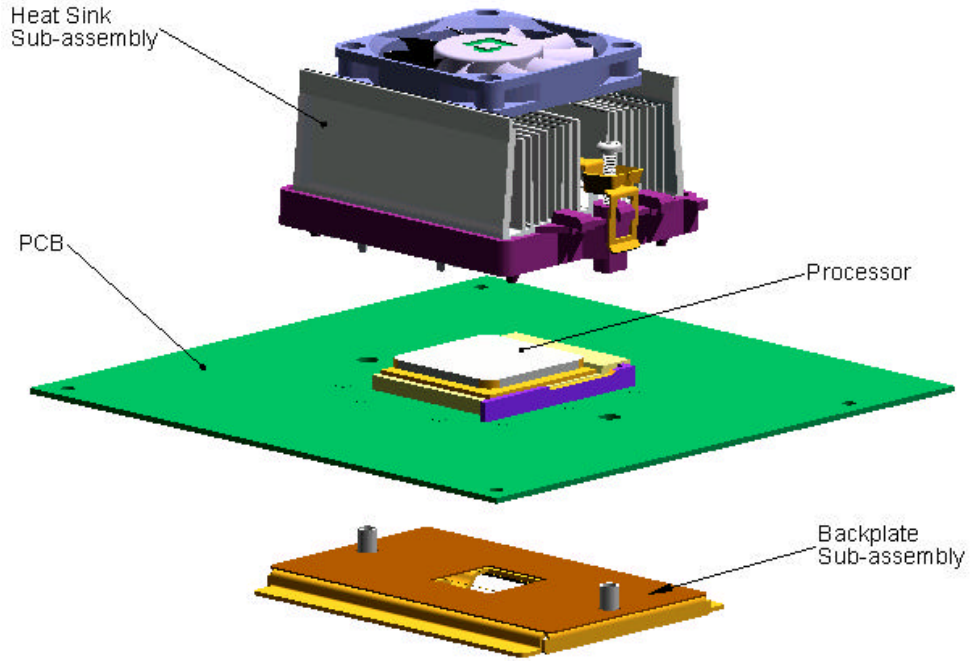
- Minimize board bowing and flexing
 - Increased reliability
- Protect Socket to motherboard solder joints
 - SMT force tolerance is limited
- Industry feedback strongly supports AMD's position of using a backplate
 - Shipping
 - Functionality
 - Long-term reliability
- Provides a solid attachment point for the heat sink mounting hardware

Reference Design Solution 1



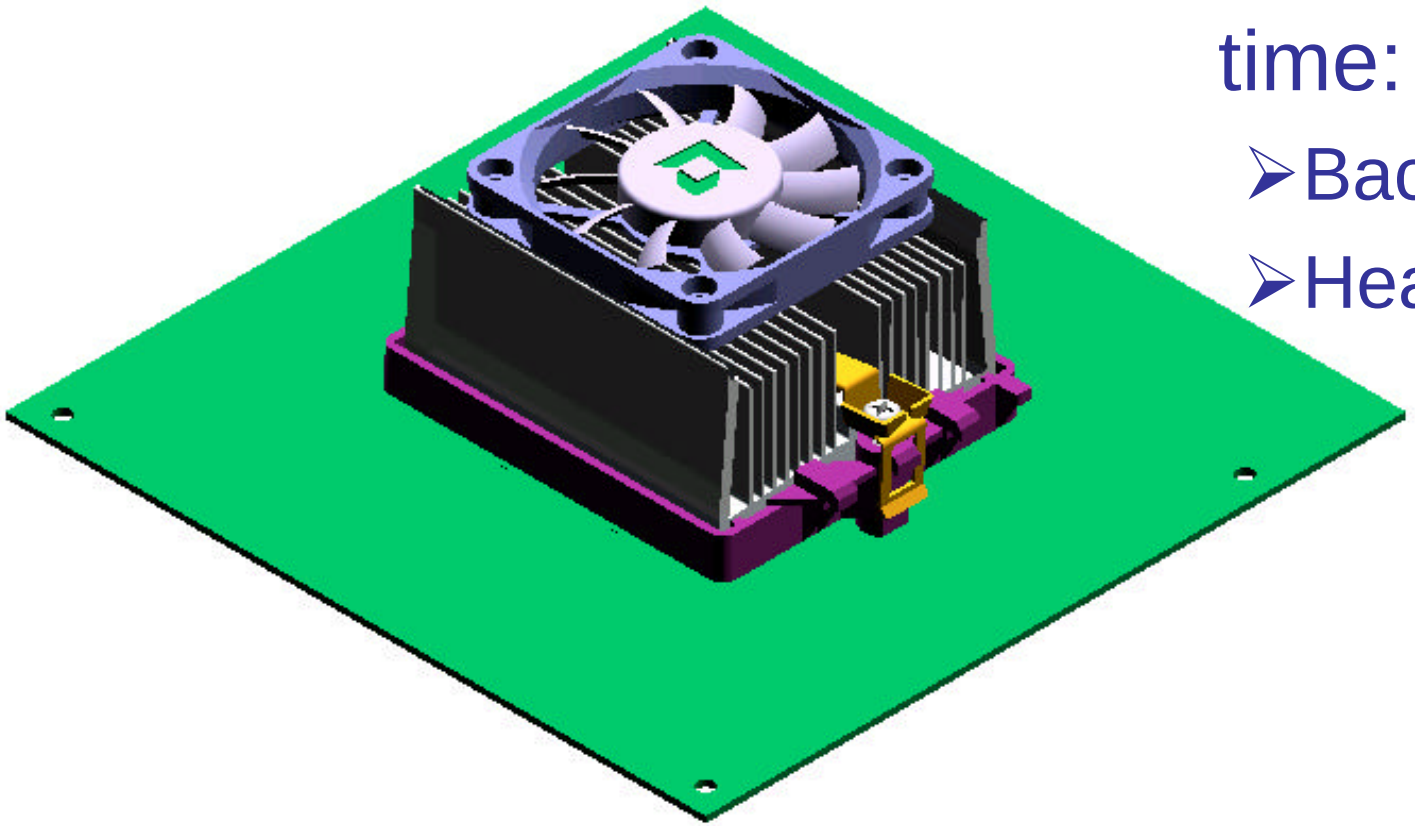
- Robust mechanical attachment
- Uses mechanical advantage of screws to load spring clip
- Uses same screw thread as most motherboard standoffs

Design Solution 1



- Solution 1 installation
 - Adhesively attach backplate
 - Prepare thermal interface
 - Align & place heat sink assembly
 - Features on backplate align to retention frame
 - Fully drive each screw

Design Solution 1 Installed

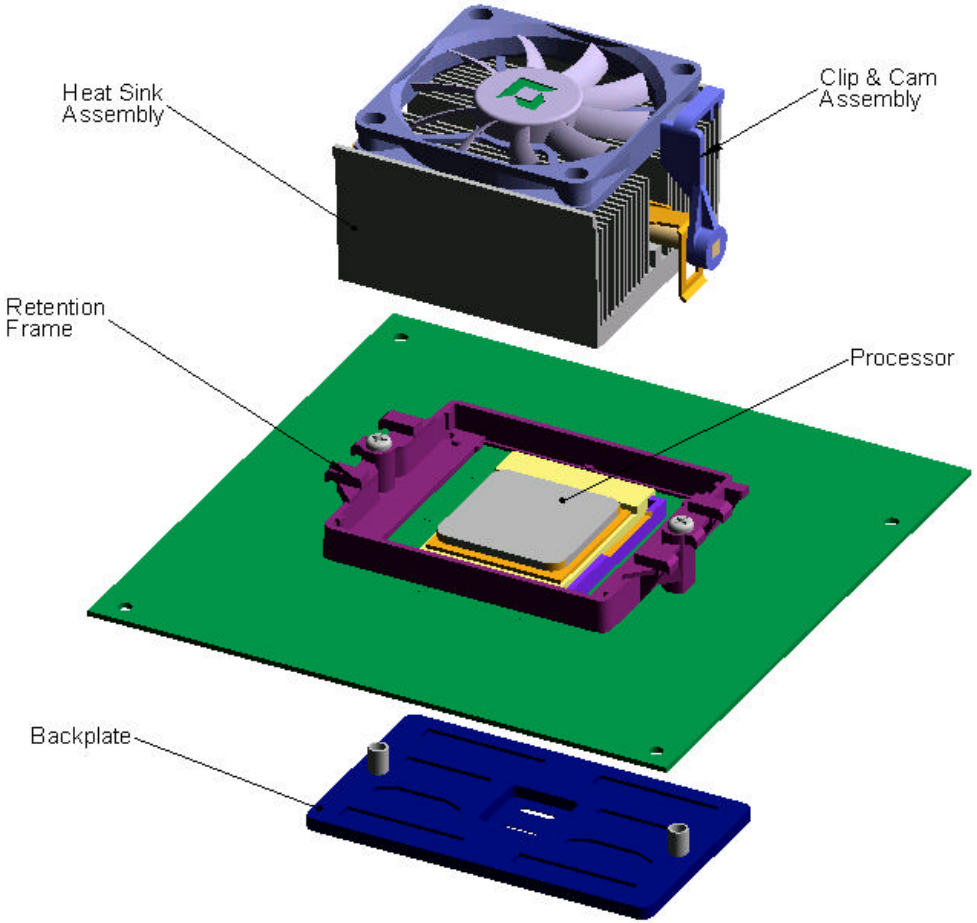


- Total installation time: ~25s
 - Backplate: 10s
 - Heat sink: 15s

Reference Design Solution 2

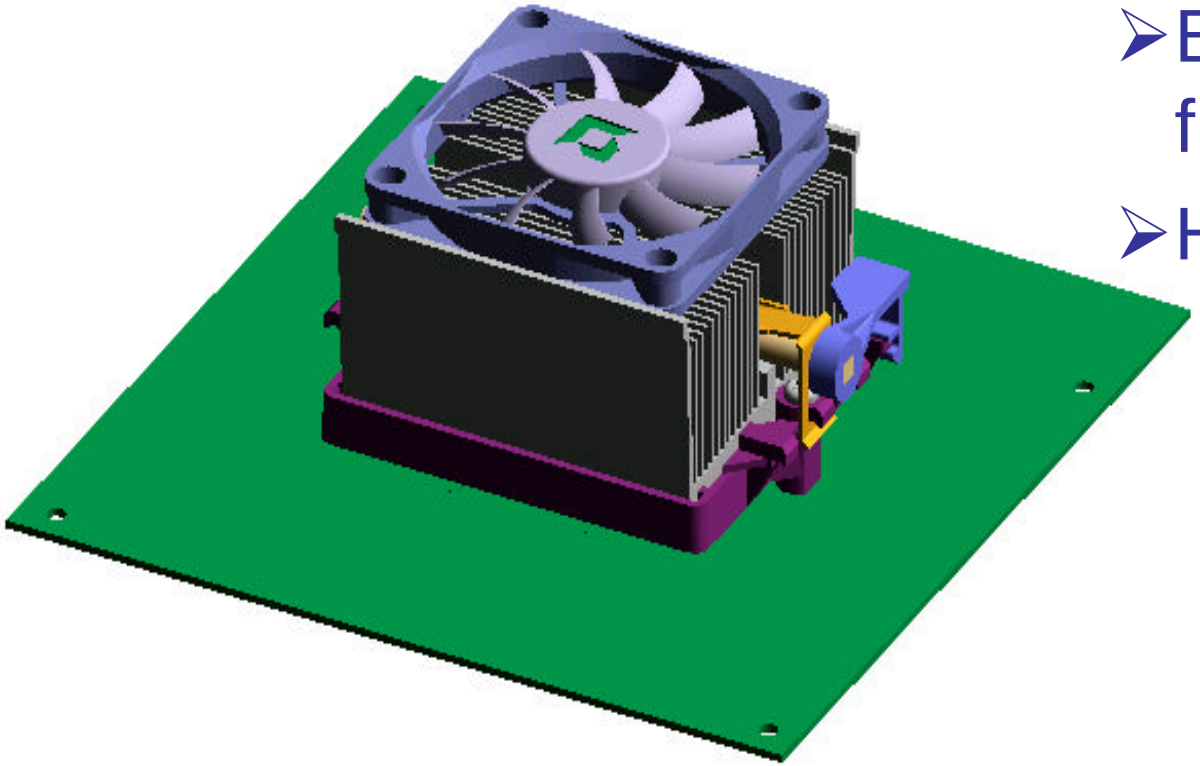
- Driven by OEM & customer feedback
- Design includes key features
 - Support frame & backplate firmly attached to motherboard by motherboard vendor
 - Heat sink attach method compatible with existing assembly and RMA process flows
 - Heat sink installation requires no tools
 - Simple field removal of heat sink

Design Solution 2



- Tool-less installation
 - Prepare thermal interface
 - Hook clip over mounting tabs on retention frame
 - Actuate cam lever to apply full load

Design Solution 2 Installed



- Total installation time: ~30s
 - Backplate & retention frame: 20-22s
 - Heat sink: 5-10s

Design Qualification

- Shock & Vibration Testing
- Drop testing
- Socket 754 qualification tests performed with thermal hardware
- Reference designs meet requirements in AMD NDA Doc. 26633 “ClawHammer Heat sink Design Guide.”

Vendor Validation

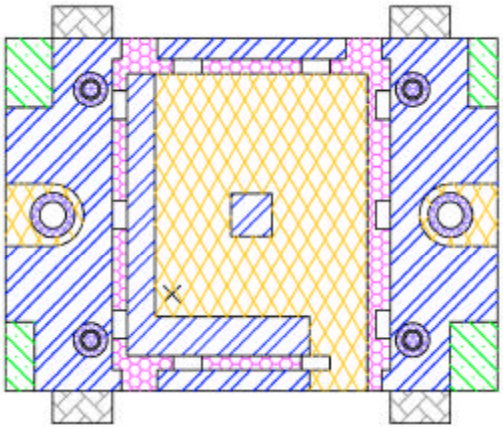
- Heat sink vendors that have produced AMD reference designs may have solutions validated by AMD
- AMD customers can use the reference designs or a vendor's custom solution that meets design requirements

Motherboard Partners

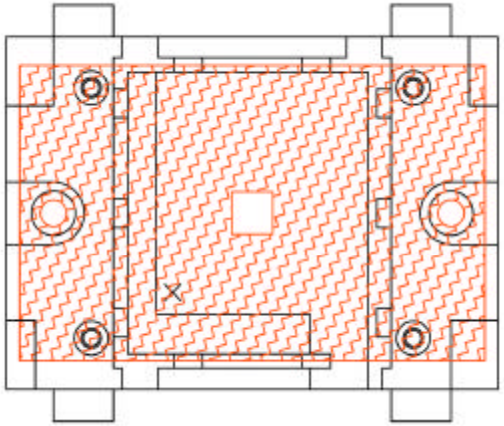
- Board referenced mounting hardware requires a standard two-hole pattern
- Keep out zones are defined to prevent interference between heat sink hardware and board components

Motherboard Keep Outs

Board Top Side

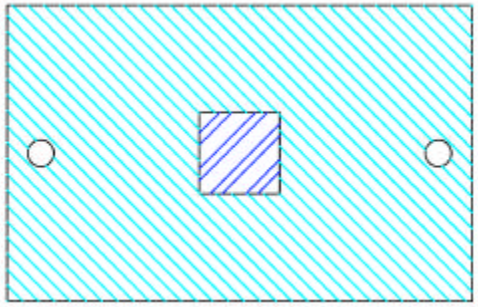


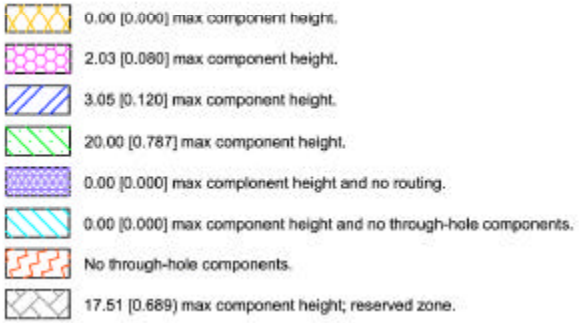
No Through-Hole Component Zone View



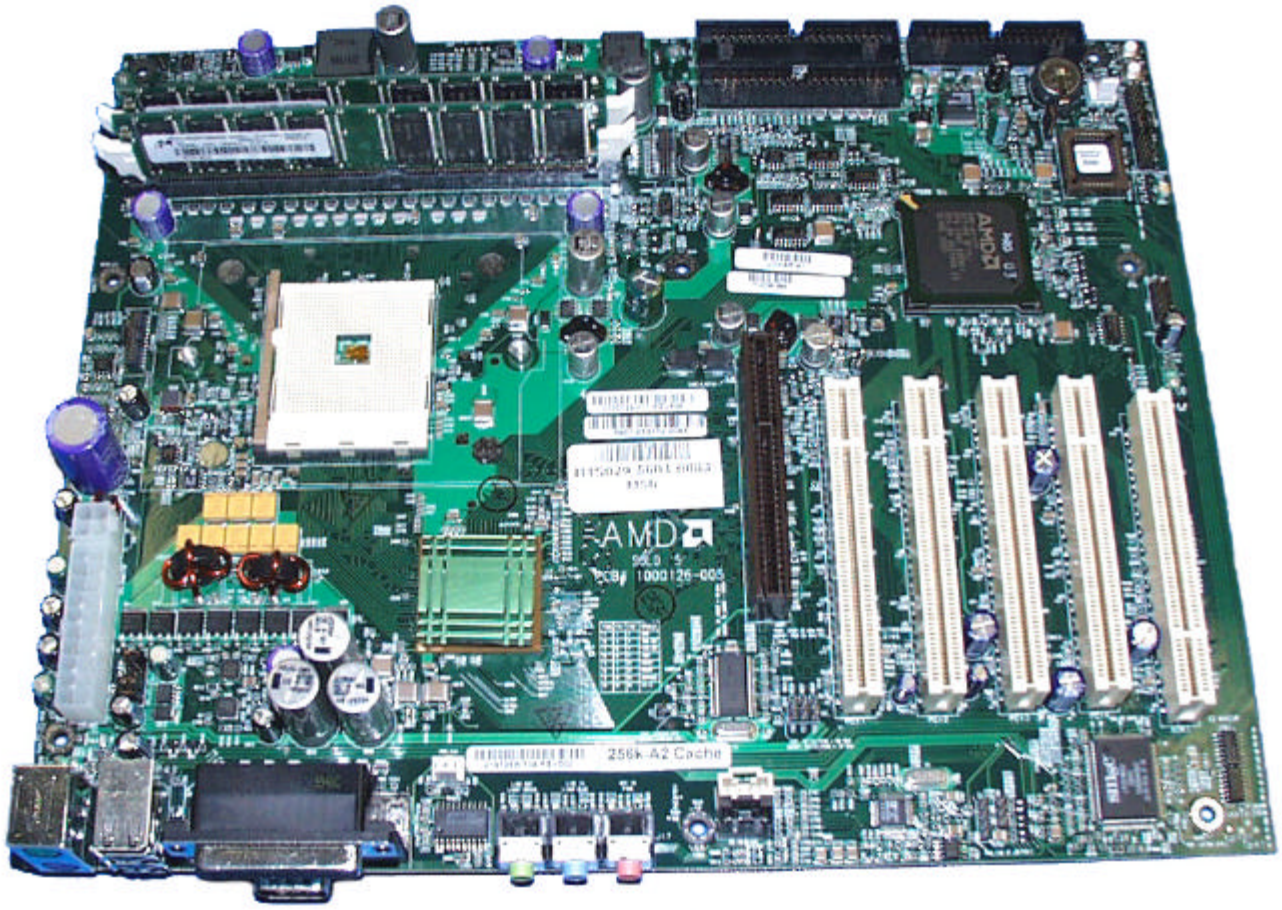
- Detailed drawing shared with motherboard vendors under NDA

Board Bottom Side





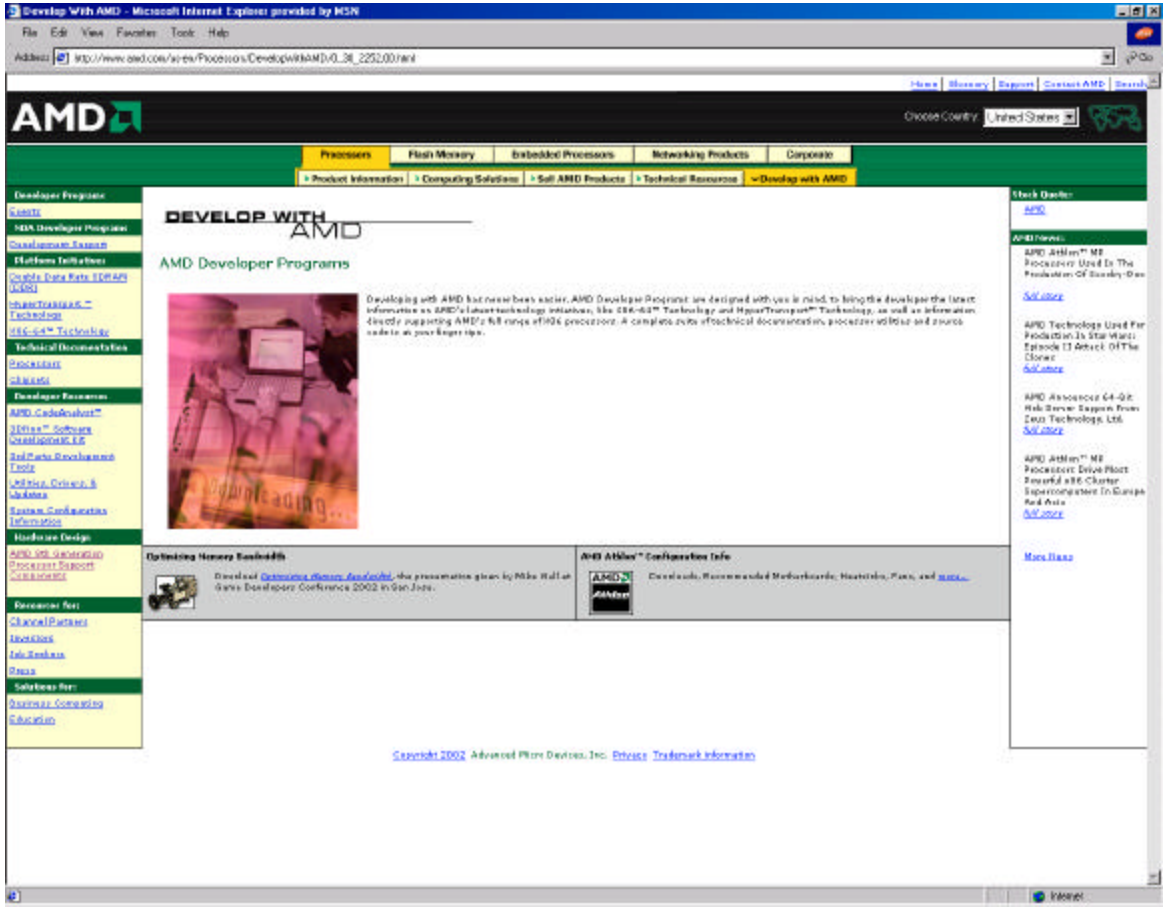
AMD Reference Motherboard



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AMD Web Site

- Contains vendor contact information
- Develop with AMD
 - AMD Eighth-Generation Processor Support Components



Summary

- AMD reference designs are tooled with development partners
- Key design features for mechanical robustness
 - Backplate to reduce board bowing
 - High clip load to prevent processor pull-out
- Customer focus drives innovation

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